DOCUMENT RESUME

ED 419 695 SE 061 422

AUTHOR Chen, Chung-Chih; Taylor, Peter Charles; Aldridge, Jill M.
TITLE Combining Quantitative and Qualitative Approaches in a Cross-National Study of Teacher Beliefs about Science.
PUB DATE 1998-04-00
NOTE 27p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (71st, San Diego, CA, April 19-22, 1998).
PUB TYPE Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Case Studies; Classroom Environment; *Constructivism (Learning); *Curriculum Development; Educational Change; Epistemology; Foreign Countries; International Studies; Learning Strategies; *Relevance (Education); Science Curriculum; *Science Education; Science Teachers; Secondary Education; *Teacher Attitudes
IDENTIFIERS Australia; Nature of Science; Taiwan

ABSTRACT

This paper reports on the latest outcomes of an ongoing cross national research project that examines the relationship between teachers' beliefs about the nature of science and the classroom learning environment from a reform-oriented constructivist perspective in junior high school science classrooms in Australia and Taiwan. The focus is on an innovative Australian science teacher who developed a pedagogy relatively free from the traditional science curriculum imperatives. The significance of this case study lies in what it can tell about how teachers who have relatively postmodern beliefs about the nature of science might go about creating classroom environments in which students' own life interests are a central focus of their learning activities. Such learning environments are of interest to those who are concerned with constructivist pedagogical reform that builds on students' extant perspectives, interests, and goals towards learning and themselves. Contains 19 references. (DDR)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED 419 695

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY
C. Chen
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
1

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
X This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

Combining Quantitative and Qualitative Approaches in a Cross-National Study of Teacher Beliefs about Science

Chung-Chih Chen
National Kaoshiung Normal University, Taiwan

Peter Charles Taylor & Jill M. Aldridge
Curtin University of Technology, Australia

Paper presented at the annual meeting of the
National Association for Research in Science Teaching (NARST)
San Diego CA, 19-23 April 1998

SE 061 432

Combining Quantitative and Qualitative Approaches in a Cross-National Study of Teacher Beliefs about Science

Chung-Chih Chen, Peter Taylor, Jill Aldridge

> This comes back to my spirituality, of man trying to be God, thinking he's got all the answers, when God, himself, can show that you're only part of the way there. . . .So, I'm constantly thrusting and parrying with the kids, about these things; questioning what we're saying is an absolute truth.
>
> [Frederick Dale, about his teaching of Yr12 Biology, Nov 1997]

INTRODUCTION

Our choice of Mr Frederick Dale was relatively straightforward. For this part of our cross-national study of science classroom learning environments, we needed an Australian teacher of junior high school science whose classroom teaching and views of the nature of science were in sympathy with (our view of) constructivist theory. There didn't seem much point in examining uninteresting teachers; perhaps if we could identify exemplary teachers in both countries then our opportunity to learn about how science can/should be taught would be greatly enhanced. We needed an experienced and confident teacher, one who could welcome strangers into his classroom.

Fred seemed to fit the bill, quite admirably. And just as well, because we were hard pressed to find another teacher with these qualities. Our recent attempts to identify such a teacher via a postal survey had been frustrating. Our newly designed questionnaire - *Beliefs About Science and School Science Questionnaire (BASSQ)* - seemed to hold considerable interpretive difficulties for many (objectivist-oriented? culturally-restrained?) teachers (Aldridge, Taylor & Chen, 1997). And the one promising respondent, who was very conversant with philosophy of science, turned out on examination to be strong on rhetoric but, disappointingly, a (self-confessed) traditionalist in his classroom practice.

PETER RECOLLECTS

As I drove toward Southside Senior High School, where Fred taught junior science and senior Biology, I recalled the many visits I had made over the years to this well-resourced government school, one of the largest schools in the state. It was there that I had conducted developmental trials of the *Constructivist Learning Environment Survey (CLES)*, another questionnaire that was to play a central role in this study (but in the next paper after this, one which focuses on the students' classroom experiences) (Taylor, Fraser & Fisher, 1997). The school was practiced at hosting visitors, and served as a major site for pre-service teacher education for another of Perth's four universities.

And it was there, five years ago, that I had taken a crew from the university's media centre to capture some of the inspiration of Fred's teaching. But now I grimaced as I recalled how I had 'invaded' his classroom with two large video cameras and brilliant halogen lights, and how I had wandered around the classroom with a boom mike trying to 'eaves-drop' on students! That I had not, at the time, been unduly concerned about

my intrusiveness speaks loudly about my earlier attitude towards classroom-based research.

What was it about Fred's teaching that had captured my enthusiasm? I think it was the way that his genuine love of and respect for science shone through his pedagogy; and, importantly, he was passionate about eliciting similar feelings in his students. In his junior science classes, Fred was a single-minded innovator, prepared to back his own judgement about how students best learn science. With a passion for a rigorous work ethic and a conviction that every student could and should learn to think and act scientifically, Fred directed students to enact an inquiry-oriented and hands-on approach to investigating the world around them. I recall excited students boiling Coke to find out how much sugar was dissolved in it. The wonder for me was that Fred succeeded, from lesson to lesson, in co-opting 30-plus students to participate enthusisatically in the realisation of his vision.

As a frequent visitor, I had witnessed students working with a sense of wonder, excitement and commitment as they performed the sort of science they believed scientists to be doing. The essence of Fred's teaching was that students were presented with rich opportunities to learn that science was about posing interesting problems, designing experiments, working collaboratively in small groups, engaging in critical reflective discussions, managing time and resources, and writing up the various stories of their learning. I had marvelled at the eclectic nature of his teaching roles - director, provocateur, task-master, counsellor - roles that he interchanged frequently as he alternated between pragmatist and visionary.

In the intervening years, Fred and I had met several times. In a recent chance encounter, he admitted to me a (sceptical?) interest in 'constructivism', but he wasn't too sure what it entailed for teaching, beyond an apparent concern for correcting students' misconceptions. This is a popular but narrow view of constructivism, one that I do not value over much, preferring to regard constructivism as a powerful tool (or epistemological referent) for critical reflective thinking about teaching and learning (Taylor, 1998). And I thought that I knew enough about Fred's teaching to tell that a primary concern for correcting students' misconceptions probably didn't fit very well with his pedagogical values. Although he did value scientific knowledge, in his Year 8 science classes he had tended to downplay the traditional pedagogical emphasis on teaching correct (factual) answers, preferring instead to emphasise the intellectual, discursive and manipulative processes of experimental science.

It was at this time that I took the opportunity to ask him to be involved in this project. He agreed to think it over and, a week later, invited me to present a workshop on constructivism at a district science teachers' professional development day. I seized this opportunity with enthusiasm, feeling that I might be able to articulate a perspective on constructivism that connected meaningfully with Fred's pedagogy. This was important to me, not because I wished to recruit him to my own (academic) ideology (as once I might have wished) or to create an(other?) opportunity for me to serve my own interests by mining his teaching for gems to sell in the academic market place.

No, I wanted to establish a relationship that was, from both our perspectives, mutually beneficial. And here, of course, lie various dilemmas. How to make a contribution without privileging my academic (theoretical) perspective. How to engage with a teacher in such a way that I experience authentic learning about the values and beliefs that shape his classroom teaching practice? Perhaps a pluralistic perspective was needed, one that holds in a *dialectial relationship* (Cobern & Taylor, 1998; Slattery, 1995; Taylor & Geelan, 1998) my theoretical interests (in constructivism and postmodernism) and the teacher's pragmatic pedagogical interests. From this perspective, both sets of interests would be articulated and reflected upon in a critical way, but neither would be assumed to have a privileged role in making sense of what is happening in the classroom.

I felt also that I needed to establish with Fred a caring and empathic relationship, based as much on emotionality as on intellectual considerations (Dawson & Taylor, 1998). So, how should I respond to the inevitable desire to praise a teacher's innovative endeavours; to reassure, perhaps, that the struggle to be creatively different from his colleagues is worthwhile? And what to do with my criticism, should there be any, of the (apparent) impact of his teaching on student learning? Indeed, do I have the right to be 'judgemental', or do I have the right not to be? And what about the quality of my relationship with the students. What is required there? Surely, the credibility of their responses to my questions will depend on their perception of my role and the interests that I appear to be serving. What if they are harbouring critical attitudes about their learning experiences; how do I tap into them and what weighting do I attach to them?

With all these issues to consider and no simple solutions to hand it is no wonder that non-participant and emotionally-detached relationships have been the norm in science classroom research!

And, so, I attended the professional development workshop and, during that afternoon, witnessed (and shared) the animated enthusiasm of other teachers for Fred's inquiry-based approach to science teaching. The thing that most excited us was Fred's apparent success in creating a practical curriculum which actively engages youngsters with learning difficulties. It was clear that Fred and I had in common a commitment to the type of teaching that engaged (all) students in meaningful and reflective learning experiences which connected with their current (and future) lives.

But it was also clear that we used quite different language to give expression to our pedagogical ideals and practices. Put simply, mine is the language of the theorist, while Fred's is the language of the practitioner. Would we, I wondered, be able to co-construct a linguistic bridge that gave each of us access to the other's expertise? A bridge that would enable us to communicate about the things that we might or might not have in common. A passionate goal for me, as a teacher educator, is to see teachers weave into the fabric of their science teaching an epistemic thread, one which reveals the inherent uncertainty of scientific knowledge, the tentativeness of scientists' theories and knowledge claims. Where, I wondered (to myself) does Fred stand on this (perchance emotive) issue?

Subsequently, Fred agreed to participate in this study. And I decided that I had learned enough from recent research into my own teaching practice that I could, with some confidence, establish a *dialogical relationship* with Fred (and perhaps with the students as well) (Taylor & Dawson, in press). For my part, I intended to show unconditional respect for Fred's teaching, to be supportive of his creative efforts and sensitive to his needs, and to generate a degree of reflective thinking in discussions about our pedagogical beliefs and values.

It was with these thoughts and (methodological) commitments dancing through my mind that I walked along the roofed and breezy outdoor pathways of the school,

through shaded gardens of native shrubs and areas of inviting lawn, and headed for Fred's Year 9 science class.

It is at this stage that I turn to the video recordings that I made during my visits to Fred's Year 9 science class in the closing weeks of the 1997 school year. The focus of these recordings was Fred's communicative interactions with students (mostly at the whole-class level) and conversations that I held with him (after class) about his pedagogical intentions, values and beliefs, and about their embodiment in his teaching actions. Here, I present several vignettes (or, to use a theatrical metaphor, 'Scenes') that are intended to portray something of the way science was represented during the opening 15 minutes of that first lesson.

As a (silent) witness to this brief episode, I experienced the classroom in a minimally interactive sense (unable to enter into communicative relationships with the teacher or students due largely to my fixation with the camcorder that I was using), but I was also maximally engaged as a thinking-feeling being, one who was fully occupied with 'making sense' of my experiences. During this time, my main referents included: my previous (rich) experiences and understandings of Fred's teaching; a critical constructivist set of valued beliefs about teaching, learning and research (Taylor, 1996, 1998); and the phenomenologist's (ontological) need to maintain a critical reflexive (pre-theoretic) awareness of my feeling-thinking experiences (Taylor, 1997; Taylor & Geelan, 1998).

These referents for my sense-making actions (observations?) would be supplemented later (during the writing phase of this and subsequent papers) by a more strongly hermeneutic concern for understanding the meaning perspectives of Fred (and his students) and of my coauthors as we negotiated the meanings of our individual experiences of Fred's teaching and of the 're-presentative' texts that we would write individually and that we would juxtapose in attempts at collaborative writing.

The epistemology of this research (fieldwork, writing) draws on the *trustworthiness* and *authenticity* standards of Guba and Lincoln's (1989) hermeneutic inquiry; the *dialogical* standards of *pedagogical thoughtfulness* of Van Manen's (1990) hermeneutic-phenomenology; and the literary standards of *impressionistic* writing of John van Maanen (199?), especially in relation to the following impressionistic tale. The putting together of the various (disparate?) (quantitative and qualitative) parts of this paper owes much to Denzin and Lincoln's (1994) notion of *bricolage*, or "a complex, dense, reflexive, collage-like creation that represents the researcher's images, understandings, and interpretations of the world or phenomenon under analysis" (p.3).

IMPRESSIONS OF THE FIRST 15 MINUTES

Scene I

I meet Fred in the science staff room. There is little time for other than brief conversation as he collects the pre-ordered tray of equipment from the lab technicians and holds fragmented conversations with colleagues who hurriedly consult him in his role as science department head. We walk together to an adjoining building where 10 or so Year 9 students are waiting quietly outside the science lab, a utilitarian room with benches, gas taps and sinks, but little else. Equipment is stored in the richly-resourced neighbouring science building and is wheeled or carried to classrooms on trollies or trays.

I move instinctively to the rear of the room where I can be relatively unobtrusive, and leave Fred to deal with the class in his usual way. He is not the sort to stand on ceremony, and will introduce me (quite informally) at an opportune moment sometime during the lesson. I perch atop a stool, switch on my (compact) camcorder, and begin to record sequences of Fred interacting with the students. It is these moments of informality before the lesson begins that I value for what they suggest about the quality of educative relationships between teacher and students.

At this stage, I have little idea about the curriculum that has been shaping the learning activities of the class for the past six weeks. All I know is that the main theme of the 10-week term is Water. This is to be my first lesson; but, for the class, it is around their 18th.

Scene II

Most of the students are sitting at benches (arranged around and within a horse-shoe setting), unpacking bags, opening files, chatting quietly with each other. Boys are sitting either alone or with other boys. Girls are sitting in groups of varying sizes. Emptied school bags are dropped to the floor. Metal framed stools clang disconcertingly against metal framed benches and screech across the linoleum covered floor.

Fred is sitting on a bench at the front of the room facing the class. He quips with students in a friendly and relaxed manner, greeting new arrivals. There is opportunity to arrive late, but not too late. It is obvious that 'law and order' are at work in this classroom; not in an oppressive sense that robs people of their humanity, but in the sense of an ethos of mutual respect and obligation at the heart of which lies clearly-defined and taken-as-shared social goals of teaching and learning. I had expected no less of Fred's class. No matter that these students had been hand picked for their inablity to succeed academically in 'normal' science classes; each one of them seems to have signed an unwritten agreement to be part of a cohesive social. Or, was this just a 'good' day?

Although Fred advises me later that some afternoon sessions can be a struggle, the social atmosphere remains positive during my subsequent (morning and afternoon) visits.

I attribute this, in small way, to Fred's unique blend of compassion and assertiveness which precludes the (very real) possibility of aggressive teaching and embittered learning that I have experienced in other classrooms where disaffected teachers and students fail to respect each others' human rights. Even when frustrated by Emma's continual subtle displays of a work ethic of minimalism and tokenism, Fred's vigorous protestation (on one occasion) seemed obviously moderated by his concern for her well-being.

Scene III

Ever the opportunist, Fred seizes a topical social issue raised enthusiastically by Ron, an issue that is currently being covered by the nation's media - public share buying in Australia's national telephone company (Telstra). Fred turns the discussion to a consideration of new communication technologies. The mood throughout the class seems to be one of interest and relaxed informality, with Fred posing 'what ifs' and students calling out their opinions. Fred stage manages the conversation; takes cues from it, ignites it, directs it, deflects it. He relates humourous anecdotes (re old technologies of his childhood) and refers to the possibilities for students' future lives of newly developing technologies.

In relation to an earlier (intimidation-free) disclosure by Carol that she had forgotten to bring her science book from home, Fred points out wryly that when they have video screens on their computers at home he can remind them about their homework. There is some embarrassed laughter. Lisa asks Fred whether he would be embarrassed to have such a call when he is in the bathroom. He responds in kind, alternating between providing technological insights and embroidering the joke.

All the while, Fred is posing questions, stimulating imaginations, connecting between science and students' lives. And all the while, he is preparing the class for the type of conversation that he wants to have about today's lesson. After several minutes, he asks the class: "Anyway, what are we doing? What are we on about at the moment, Sarah?"

In questioning discussion, he helps the students establish that they have been examining the water content of soils (within the broader 10-week topic of Water). He questions the rationale of students' experimental method (i.e., comparing samples of black and white soils that he encouraged them to collect from the school garden during class time).

In this transition, Fred seems to be skilfully constraining student thinking, from the social anarchy of the playground, to the focused free-play of the first few minutes of class, to the ever-sharpening thinking about the main learning activity. This is not an authoritarian teacher demanding instant compliance and single-minded cultural reproduction. There is a firm-yet-soft insistence about Fred's manner as he channels students' consciousness towards recollection, the re-making of conceptual connections, re-focussing, re-establishing continuity of learning. I admire his personable approach and his easy rapport with students, both individually and collectively, an approach that I had developed with senior physics classes, but which had (all but) eluded me when facing classes of 30-plus in the junior years. Fred's questioning seems safe, inviting, but insistent.

Scene IV

He invites the class to make a prediction about the outcome of the experiment (of comparing the water content of the soil samples): "Who can make a prediction as to which one might have the most water in it?" *[scanning the class, pausing]*

He canvasses various students' opinions, not judging them right or wrong but trying to engage them purposefully in thinking about the activity that they have been conducting and which they are to resume today. He summarises students' reponses: "And quite a few in here predict that there might be more water in the black sand. Was that right?" *[inquiring warmly of the boys closest to him]* "Was it the black sand which might have more water in?" *[the boys concur, almost inaudibly]*

And, then, without confirming or denying the viability of the prediction, he moves to the blackboard, and suddenly the intellectual demand increases dramatically, or so I suppose given the backgrounds of many of the students: "But look at this, class!" *[emphasising 'look' as a magician might introduce an illusion]* "I've got two samples of soil".

On the board, he sketches (in white chalk) the 2 petri dishes and their soil samples. In questioning discussion, he establishes that there is likely to be differing amounts of soil in each sample and, thus, that measurements of water content (obtained by students' current practice of measuring the samples before and after drying) do not allow meaningful comparisons to be made. Instead, he directs, they are to "find out a percentage" for each sample. I reason that the goal of Fred's teaching is not gross water content, but (what I call) the differential water holding capacity of the two soils. He now seems to be trying to position this as the prime goal of students' subsequent investigations. He explains the mathematical algorithm which he writes on the blackboard ("loss/mass" *100).

So, what is happening here? Fred seems purposefully to be making problematic students' experimental methods. During the previous class, he must have detected the problem that he is using now as a teaching point. It is not possible for me to diagnose the extent of this problem, but it seems likely that it is widespread. Why so? Because proportional reasoning lies at the heart of the solution to the problem. This is a notoriously difficult concept when dealt with formally in the mathematics class. But, perhaps, it is not so difficult when set in a familiar context? This is a major reason for my preference to teach mathematics in contexts that students find meaningful.

Scene V

And it is a context of meaningfulness that Fred then attempts to bring to the class as he introduces an analogy to promote understanding of the scientific concept (of differential water holding capacity) and the applied mathematical skill of proportional reasoning. The analogy concerns the water content of Fred's body compared with that of Ryan, one of the boys sitting nearby.

"In terms of pure quantity, the amount, who might have the most? *[he inquires invitingly of the class]*
"You!" *[volunteer various students in a confident tone]*
"*Me*, because I'm the most, probably 80 kilos". "What are you?", asks Fred *[pointing to Ryan whose response is inaudible to me]...*
"Fifty-five!" [Fred announces enthusiastically] "So, probably I've got, **in quantity**, more water!"

[Fred seems, initially, to be agreeing with the students, but is really entrapping them within the logical consistency of their own frail reasoning]

"But **really**"*[spoken with an intonation of intrigue that characterises much of his discourse]*
"if we looked **in between** the tissues, the bones, and the other bits and pieces [gesticulating and scanning the class] that make up Ryan and me, which one might be more flooded in water?"
"You?" *[students reply hesitatingly, perhaps anticipating one of Fred's characteristic reflective turns]*
"Might be" *[he offers neutrally]*. "It might be him!" *[he exclaims and pauses momentarily for dramatic effect]* . . . . "It may be that I've dried out in my old age". [he states ironically]

"What we are really trying to see is *[clarifying the prime learning goal]* . . . which soil has got the most water, not in terms of just quantity but how much per unit of soil" *[rushed and spoken quietly, offered almost apologetically, as though it was unpalatable medicine; scans the class and sees some heads nodding in agreement]*

[Pausing and changing the focus to learning per se]
"Am I making sense to you, **a bit**?"

[offering solace to those whose grasp of this complex idea is slippery, and honoring their effort to engage in thinking about the issue over the quality of the outcome?]

In questioning conversation, Fred proceeds to explain that a percentage calculation is required to compare the water content in his and Ryan's (different sized) bodies. With a personalised analogy and some humour, Fred attempts to help the class understand how to control an important experimental variable, the variable of soil mass (but without using that formal language). And, perhaps aware that this mathematical approach is not being understood by all, he attempts to ameliorate confusion and anxiety (which are well hidden from me but which are probably being detected in his reading of students' body language) with a softener, that he hopes they understand at least "a bit".

But why, I muse, didn't he get them, at the beginning, to measure accurately their sample sizes and thus avoid the need for this post-hoc mathematical remediation?

Scene VI

Almost in answer to my silent query, Fred asks the class:
"What should we have done to make this easier from the start? Taking...?" *[upward inflection indicating a single correct answer]*
"Same amounts!" *[confidently volunteered by Jane at the rear of the class]*
"The **exact same amounts** of soil each time! Then we could have had a direct comparison". *[Fred states brightly, acknowledging Jane's insightful reply]*
"But that's **a bit fiddly** *[a change of mood to one of being troubled]*...trying to get the exact same amount...you're spooning some off and spooning some on". *[gesticulating and indicating the tedious nature of this approach]*

ANOTHER METHODOLOGICAL INTERLUDE

So, what are Fred's beliefs about science and what relationship do they bear with his teaching? Which of his valued beliefs are embodied in his classroom actions? And, what type of understandings about the nature of science does he want students to construct from their experiences in his science class?

My previous experiences of Fred had led me to believe that he is a reflective teacher, more so than many of the teachers who enrol in our graduate programs. In previous conversations, he had struck me as someone who was able (indeed, enjoyed the opportunity) to articulate quite clearly his professional values. And he does so with a quiet conviction bordering on passion. In past conversations, it soon becomes evident that Fred has committed a large part of his life to teaching, to providing students with rich opportunities to experience science 'from the inside' and, importantly, to crafting students' engagement in these life-enhancing opportunities. Although he is an innovative teacher, always ready to try something new if it might result in more of his students being 'turned on' (to thinking/acting scientifically), his innovations are carefully measured rather than chaotic or haphazard. Fred can be relied on to provide a sound rationale for his teaching.

So, it was with a sense of expectation that I turned the camcorder on him at the end of the lesson described (in part) above and asked about his teaching goals. And, I followed up on this conversation at the end of several subsequent lessons. On one occasion, we relocated to the staff room where he completed the *Beliefs About School Science Questionnaire (BASSQ)* (see Appendix and Figs 1 and 2) that we had been developing as one of the research tools for our cross-national study. He spoke aloud as he considered each item in turn, enabling me to record his commentary. Thus, I was able to identify his interpretive difficulties and understand better why the questionnaire needed to be modified if was to be of use in surveying other science teachers' (espoused) beliefs.

On the next occasion, we sought a small room usually used for parent-teacher consultations, and about an hour in a broad-ranging discussion about his philosophy of science teaching and the ways in which his teaching actions embody his valued beliefs, beliefs about learning, about his students, and about science.

What I learned from those conversations was that Fred does have a clearly articulated philosophy of science teaching, but not one that is homogeneous; not one that he applies consistently on all occasions to all science classes. Fred's view of the nature of science comprises (what I would call) a pragmatic mixture of valued beliefs. The chief characteristics are portrayed in the following interpretive account, one which is framed by my own (critical constructivist) perspective and which draws on my recent experiences in Fred's Yr 9 science class (especially The First 15 Minutes). Interspersed throughout this account are extracts of recorded conversations with Fred which lend his supportive voice to my claims about the nature of his philosophy of science teaching.

Although I did not seek to interrogate him about his espoused beliefs, preferring to maintain the *ontological authenticity* of our relationship (Guba & Lincoln, 1989), I remained alert to the possible presence of inconsistencies in his claims and to (less readily detectable) cultural myths which underpin 'natural attitudes' and govern the social actions of teachers of science and mathematics (Taylor, 1996; Tobin & McRobbie, 1996).

PETER'S INTERPRETIVE REFLECTIONS

Fred's responses to the BASSQ, (see Fig 1) indicate that, relative to his peers, he has a strong belief in *science as a process of inquiry*. In the following interpretive commentary, I identify the central thesis of Fred's pedagogy as enabling this special class of Year 9

students to learn how to act scientifically in life, in their own lives. In terms of my critical constructivist perspective, I interpret Fred's pedagogical *modus operandi* for achieving this primary pedagogical goal as one of endeavouring to engage students in open and critical discourses about their own processes of scientific (experimental) inquiry.

Acting Scientifically in Life

In reflecting on The First 15 Minutes episode, what I thought that I may have been witnessing was Fred signalling (implicitly) to the class that it's ok for them to have gone ahead with their experiments in the ways that they believed initially were meaningful, that he valued and respected their experimental designs, but that it is important also to revise experimental approaches in light of any inadequacies which scientific thinking might reveal. And, in Scenes IV and V, it is scientific thinking that Fred is modelling (animatedly) while trying to elicit the same from students.

Although he values experimental activity, it is not as an end-in-itself but as a means to engage students in learning how to think and act scientifically and, thus, to exercise some control (or discriminating power) over their own lives. Notwithstanding his choice of the topic of Water on the grounds that it is relevant to students' daily lives, the conceptual aspects of the topic do not constitute Fred's primary pedagogical goal:

> I'm on about learning, not teaching. I'm not about teaching some aspects of science....I'm not about teaching certain aspects of water, because they will always be forgotten.
> [Interview, 17 Nov 97]

> For a student who's going thru a more academic sort of instruction...it's necessary to have certain information to proceed to the next step. With these [Year 9] students, a high priority, in my opinion, is learning; the learning process.
> And the learning process is the ways of obtaining information, the ways of making information relevant, using it in their lives, getting the appropriate information when they want it; how does it apply to them?
> The social sort of skills involved with education is where they're really lacking....They don't have the confidence in themselves to do these things. So, I'd like to think of my class as being a learning class where lots of these processes are taking place, and science just happens to be the tool that I'm using to try and develop the learning skills.
> [Interview, 20 Nov 97]

> In the [new curriculum framework] what we're looking at is a sort of person, rather than what knowledge....Is it a person who can evaluate information or build on previous ideas...and start synthesising out correct information, can explain cause and effect relationships.
> So, the skills of science are becoming more important than the content. The content is just another tool to enable these things to go ahead.
> So, that's why I'm spending so much time with that Year 9, on their life skills, their reacting to each other, how they perceive each other, how they can work effectively as a group.
> [Interview, 27 Nov 97]

It is likely that Fred had, in previous classes, provided structured opportunities for students to design their own experimental procedures. Having supplied measuring equipment and encouraged them to proceed, he detected (not surprisingly) a lack of scientific thinking, a lack of critical self-evaluation about their own discursive practices. This was evident as a widespread failure (perhaps an inability? perhaps a lack of judgement?) to recognise and then control an important mediating variable (i.e., soil mass). But Fred's pedagogical goal was not so much concerned with developing (technical) knowledge of the specific water carrying capacity of actual soils. No, his primary goal was concerned with the 'bigger picture' of developing (self-empowering)

understanding of how to (re)design scientific experiments in order to take account of key mediating variables and of the powerful role of mathematics as a tool in that process.

Open Discourse

However, this goal of higher-level (scientific) thinking was not one that Fred wished to formalise with these 'at risk' students. Indeed, he purposefully steered clear of a formal discourse peppered with mystifying (and disempowering) canonical terminology such as 'variables', 'mass', 'control', 'proportion' and 'capacity'. Instead, he chose (with consummate care) to craft a language that was accessible to the students, (what I call) an *open discourse* of largely familiar terminology and characterised by attentive listening and self-disclosure of developing understanding (Dawson & Taylor, in press; Taylor & Campbell-Williams, 1994). The co-creation of such a discourse requires students to place their trust in the teacher; to trust that the disclosure of their understandings, guesses, opinions, and half-formed ideas will be respected and responded to in a helpful way.

In Scenes II and III, we witness Fred reaching out to capture the trust and enthusiasm of his students, easing them into the (enjoyable) practice of talking about their ideas, considering the value of science (and technology) in their lives, and experiencing (he would hope) the discriminating power of scientific thinking. This is by no means an easy task with a class in which failure to learn science has been a common experience during (at least) the past two years.

While being committed to engaging these students in the discursive practices of experimental science, Fred is aware of the social and emotional challenges being experienced daily by these 'super-charged' adolescents:

> They come in to the world...they think it doesn't matter what they do; they react instantaneously, stimulus response...Their lives are like that, a little bit.
> Students at the Year 9 level, and these students in particular, it's hard to get them to tap into their own perplexity....I think you would be able to tap into it more in students who are a bit more at ease with themselves...thinking about the world in general, rather than just their own life. These students are *really in* to their own personal issues...their relationship with others, how they are perceived by others, and so this is why they're stimulus response type. [Interview, 20 Nov 97]

Fred's understanding of these students (as people) is translated into an attitude of care and compassion; and his personableness (evident in Scenes II and III) serves him well in creating a learning environment in which open discourse can (begin) to flourish:

> Fred You have to be authentic with these kids...being truthful to them...
> Peter You make a big deal at the beginning of the class to connect with the kids, I noticed, talk with them.
> Fred Yes, they need that...relationship. That's what I'm meaning by authentic: you have to genuinely show warmth with the students...and you can't be judgemental....They will say outlandish things...swear...And, whilst you don't accept, [don't] show warmth to that or show great acceptance, you can still like the person; but you can say, "Hey, what did you just say?",...rather than the coming down as an authoritarian....You can still correct, but in a way which still has warmth in it...and don't be too degrading, but just...massage it a little, just tease it a bit, "And what does this mean for you?"; and leave it open for them to make their own judgements in the end. [Interview , 20 Nov 97]

But this is only half of the challenge that drives Fred. Because he knows that if he is to move students forward, to enculturate them in the discursive practices of science, then he must also enable them to reconstruct themselves, not only in the sense of becoming more knowledgeable, but in becoming critical self-reflective inquirers who can question the viability of their own inquiry processes and the knowledge claims that emanate from them.

So, it is with this aim in mind that Fred weaves (with artful pedagogical skill) the powerful thread of (what I call) *critical discourse* (Dawson & Taylor, in press; Taylor & Campbell-Williams, 1994) into his educative relationships with these students. Critical discourse is characterised by asking challenging questions of others - challenging others (students, teacher) to justify their ideas and knowledge claims - for the (ultimate) purpose of examining critically the (often invisible) assumptions underpinning one's own thoughts and actions. In Scenes IV and V, where Fred is endeavouring to provoke students into thinking self-critically about their own experimental designs, he is using critical discourse to model scientific thinking. Even for these so-called 'low achieving' students, his pedagogical goal is to equip them with the necessary (discursive) skills for reflecting critically on the viability of their own ideas and actions; a skill that he hopes they will take out of the classroom and into their daily lives, especially when considering the role of science in society:

> So, what I'm looking at, really, is being able to have the students find out the sort of things that are relevant to them; how does it impact upon them and their lives? To find out, tease out some of the ideas, to question things which are presented in front of them, to be able feel confident, to be able to say things. [Interview, 20 Nov 97]

> [In relation to the uses of science]...empowering them to say things. It doesn't matter if what they say is wrong, at least they've been empowered to say something. If they're also capable of listening to others, they might be able to change what their views were. As opposed to a person who just blindly accepts and doesn't question or challenge, or feel empowered to be able to do that. [Interview, 27 Nov 97]

An important feature of Fred's pedagogy, and one that I recognise from my own attempts to create empowering educative relationships with adult learners (Geelan & Taylor, 1997; Taylor & Dawson, in press), is the necessary *co-existence* of open and critical discourses. Importantly, Fred weaves them together, knowing that it takes a sense of self-confidence for students to deal with critical questions, to be able not only to respond to them but to ask them as well. And to the extent that he succeeds, he endeavours to build on students' questions and create a spirit of critical inquiry:

> If these students *like* science, they're *confident* about speaking out, and they don't *fear* me, and that they feel comfortable that they can raise a question without being put down by others or by me. And, I know, sometimes I'll get a bit angry with the kids, and what they're doing. I want to maintain certain standards; it's not free-reign stuff, in the class. But if you can get that...*trust* in each other, and...they can ask questions. Then, I like to take science from their own inquiry, and work from there, rather than impose something on them....They can use their skills, like inquiry, and not accept blind facts....Grow [their sense of perplexity]...challenge them; just don't give straight forward answers to issues! Hear both sides! [Interview, 20 Nov 97]

According to his responses to the BASSQ (see Fig 1), relative to his peers, he believes with some conviction in the provisional status of scientific knowledge; regarding scientific knowledge as being largely a human construction that is necessarily partial

and incomplete. At the same time, he believes also that science provides us with an increasingly 'better' understanding of the natural world. He enjoys the intellectual challenge of sparring with his senior Biology students over the epistemic status of the knowledge claims of canonical science:

> [In Year 12] you're playing with a concept...encouraging them to be thinking bigger and deeper than at a [junior] level. "Life has so much more to offer now that you've grown up a bit". And so I would present to them...from personal experience, saying, "I find it interesting and fascinating, and I'm just amazed at how man just goes and makes rules up and classification systems and puts thngs in boxes and he makes statements and they're always found to be false...there's always an exception. Life is so fascinating that it will throw up an exception just to wipe that little rule out".
> So, this comes back to my spirituality, of man trying to be God, thinking he's got all the answers, when God, himself, can show that you're only part of the way there.
> That's for Year 12s....I try to bring that sort of *inquiry* excitement, that there's lots to be learnt....You make a statement like 'leaves have stomates' and then you bloody go find one that doesn't....So, I'm constantly thrusting and parrying with the kids, about these things; questioning what we're saying is an absolute truth. [Interview, 20 Nov 1997]

In the critical discourse of this Year 9 science class, Fred chooses, however, not to address the issue of *the status of scientific knowledge*. His preferred pedagogical emphasis is on the process of inquiry rather than on scientific concepts *per se*. And in relation to the conceptual side of science, he feels that these relatively immature students need to construct a platform of epistemic certainty rather than engage in deconstructing that which they barely understand.

> You're caught in a dilemma...you're trying to have students have a base of knowledge from which to question and go further; and so, sometimes, you can't have this, this underlying dilemma...about what is truth and what is not truth, as a starting point. You can teach a student somehing and then show that what you've taught is wrong, 'knock them for six'. Then you have to pick them up off the floor and say 'What are we on about?'.
> You have to keep in mind where the kids are at in their lives, and they need to find some truths and some understandings because in dealing with science; put a bit of metal in the electric plug, they're going to get zapped.... [Interview, 27 Nov 97]

> As we start heading down the track in science, we start growing up and challenging some of the things which we've accepted....We start realising the limitations of the people who've made those decisons in the past. Maybe they were clouded in their own thinking and thought processes. Maybe they were funded by certain people which had a certain vested interest.
> And then when we're really starting to grow up, we have a look at our selves today. We have alook at our [government science institutions]; we have a look at our politicians. And [at] what are the things that are impacting upon these people in their decison making today. And then we're really getting up into [Year 12] level thinking. And we start loooking at out our logging of the forests. And we start making evaluations of what is the truth here. If there is an argument, there might not be a definite truth; there might be for and against. [Interview, 27 Nov 97]

A FINAL METHODOLOGICAL INTERLUDE

In closing this paper, we are bound to address the question of how to judge the quality of this research report.

On the one hand, (some of) the *trustworthiness* and *authenticity* standards of 'fourth generation evaluation' (Guba & Lincoln, 1989) are appropriate. In drawing inferences

from observations, interviews and surveys about the relationship between Fred's beliefs about the nature of school science and his classroom actions, we utilised multiple perspectives and triangulation strategies. The *First 15 Minutes* tale was given to Fred and his opinion about the accuracy of our portrayal of his pedagogical beliefs and intentions was sought (i.e., a 'member check'). A preliminary consultation with Fred indicates that he is not dissatisfied with any aspects of the tale, believing that it captures clearly his main pedagogical intentions. Nevertheless, we do intend to conduct a more intensive consultation as part of the ongoing nature of this study. For the moment we are reasonably satisfied with the *credibility* of our inferences about Fred. Further research will include students' perspectives and, perhaps, Fred's own *signature* as a coauthor.

We are very satisfied with the *authenticity* of the research, particularly the extent of our sensitivity to the communicative relationship between Peter and Fred. We believe that the research impacted on Fred in a positive manner, providing him with a sense of enhanced worthwhileness as an innovative teacher and with opportunities to reflect on his own ideals and values. Of course, this claim must be supported by evidence - principally Fred's perspective - and this is will be one of the foci of when next we consult him.

Although the fieldwork was not of a very long duration, we argue that because of (1) our prior knowledge of Fred's pedagogy, (2) the pedagogical sensitivity of our hermeneutic-phenomenological inquiry, and (3) the well-defined focus of our research, we were able to readily 'tap' into essential attributes of the learning environment and represent them with a high degree of credibility.

The other main standard for judging the quality of this research concerns its contribution to the enrichment of the cross-national research relationship between Peter and Chen. In the short-term, we refer to the extent to which Chen was enabled, as a result of interacting with the text of Peter's impressionistic tale (*The First 15 Minutes*), to become thoughful about his own pedagogy as a teacher educator involved in constructivist-related reform of Taiwanese school science teaching. The tale was written in accordance with the criteria of hermeneutic-phenomenology proposed by Max van Manen (1991), namely those of *orientation, strength, richness,* and *depth* (Taylor & Geelan, 1998). Chen's *narrative commentary* (Shulman, 1992) on the tale (see below) reveals something of the quality of his own phenomenological-hermeneutic experience with the text.

In the longer-term, Chen will write a similar tale about an exemplary Taiwanese science teacher and Peter will have the opportunity to become thoughtful about his own assumptions about what constitutes exemplary teacher-student relationships in Australian school science classrooms.

CHEN'S PERSPECTIVE

Commentary on the Tale of Fred

Having read Peter's impressionistic tale about the learning environment in the first 15 minutes of Fred's class, I am so absorbed by the rich interpretation captured that I feel Fred seems to have appeared above the paper.

Based on my own observations of Fred's teaching and on Peter's tale, I admire Fred's teaching so much that I don't think I have ever come across any good teacher like him before. The reasons come from the following respects:

I. He is a well-qualified teacher in himself. He is full of enthusiasm in helping those low-achieving students. I think the first essential requirement for a teacher to be able to create a positive classroom environment is that he must have a strong feeling of interest in understanding them and in making good relationship with them. From the tale, we

see that he quips with students in a friendly and relaxed manner (scene II), greets the not-too-late arrivals (scene II), etc. Such behaviors seem to be a warm support for the students. This easy rapport with the students renders students to feel free to join in the learning activities and volunteer to disclose their internal thinking. It is much harder for a teacher to build up a cohesive force than just cover the content knowledge in technician manner.

II. Fred's epistemological belief in the nature of science is more than constructivism criterion.

He believes in the provisional status of scientific knowledge (P9). Furthermore, he understands the immature students need to construct enough knowledge before they can realize the tentative nature of scientific knowledge (P10)

I strongly admire constructivist classroom environment which reflect his belief in science as a process of inquiry and emphasises the constructivist nature of science"

(1) For a student to construct a new idea, the student must be at the center of the classroom activity. We can tell that Fred is quite aware of this by his stress on learning instead of teaching (17&20 Nov.97.P6). And, he also mentioned that it is a sort of person which is looked at rather than knowledge in the curriculum framework (27 Nov.97)

(2) The students are accessible to both hands-on and minds-on learning activities, Fred brings the pre-ordered equipment (scene I) for students to conduct an experiment and exercises several minds-on activities of intellectual demand, such as inviting the class to make a prediction, engaging students to think, and making problematic student's experimental methods for students to clarify (scene IV).

(3) Fred uses an analogy familiar to the student to promote students' understanding of a new scientific concept. This is in accordance with the constructivist advocation that the understanding of new information is always built on learner's existing knowledge.

(4) In inviting the class to make a prediction and think, Fred pauses (scene IV) before canvassing students' opinions. He allows the student time for them to organize their thoughts.

(5) As to the social constructivist viewpoint, Fred is quite aware of the importance of the social sort of learning skills when he points out that the students are really lacking. Since this is a description o the beginning 15 minutes, how much negotiation has taken place among the students we might not be able to see. But from the arrangement that the students sit at benches around a horse-shoe setting and small-group setting that happens (scene II), I may imagine it is favourable for the students to exchange their ideas.

(6) Fred values the pedagogical goal of making the learning process relevant and applicable to students' every-day lives (20 Nov 97).

(7) The main goal of Fred's teaching is trying to make the students to adapt to the reasoning patterns of everyday life as well as science. This can be seen from his endeavouring to have students find out relevant things and the way of impact on their lives, and to be able to feel confident.

The Situation in Taiwan

Fred's teaching which is so attractive provides a contrast to the prevailing status of teaching in Taiwan.

The heritage of the civil service examination system of Old China still makes Chinese people obsessed with higher education. The school children expect to enter prestigious schools of every levels. The National Entrance Examination serves the decisive chance to determine who will pass. Keen competition arises among students, among parents, among schools, and even among school districts. The high competition makes students cram a lot of factual knowledge and exercise repeatedly lots of algorithmic calculations. To prepare for the Big Exam, the students usually spend all

their evenings, weekends and holidays studying at home or even attending commercial cram schools over several years. For science teachers, the main concern is the coverage of the nation-wide text book and stuffing the students with the test items which ever or might appear in the Big Exam. In this sense, students are knowledge vessels instead of living organisms.

In science classrooms, students sit quietly trying to pay attention to their teacher's lecture just like students are isolated from one another. Social negotiation process is uncommon among students. The science textbook is academically based which stresses the systematic representation of formal framework of science theory. The personal relevance to everyday life is not much concerned. For most students, learning science is a frustrating experience. Utilitarianism serves as the unique motivation for students to study science.

For many years, many educators have noticed this biased practice of science teaching and have spoken up in demand of educational reform. Complying with the high-level voice, the Ministry of Education has issued a series of actions to be taken. From my personal point of view, the most urgent is the re-eduation of in-service teachers who have built very much high inertia in keeping track of the traditional belief.

A Personal Vision

At this time when voices of education reform are forthcoming , Fred's tale gives me some clues for teachers to establish positive classroom environments:

- Students are constructionists in the learning process. An easy rapport with the students helps them to feel free to learn in a constructivist way.
- Teaching students the process of how to learn is more important than the coverage of what to learn in order for students to act scientifically in everyday life.
- Creating classroom negotiation for students to reach a consensus is a process similar to how scinece knowledge is constructed in the science community.
- Teachers' belief in the tentative status of scientific knowledge and in the the enquiry process of the nature of science is favourable for creating a positive classroom environment.
- Encourage students to think reflectively is helpful for reinforcing students' learning.

IN CLOSING

This paper reports the latest outcomes of an ongoing cross-national research project that is examining the relationship between teachers' beliefs (about the nature of science) and the classroom learning environment (particularly from a reform-oriented constructivist perspective) in junior science classrooms in Australia and Taiwan.

In this paper, we have focussed on an innovative Australian science teacher - Mr Frederick Dale - who has seized the opportunity to develop a pedagogy relatively free from traditional science curriculum imperatives which prioritise the teaching of scientific 'facts'. In contrast, Fred has prioritised *learning to act scientifically in life* as a primary goal for his non-academically aspiring group of Year 9s. The significance of this case study lies in what it can tell us about how teachers who have relatively postmodern beliefs about the nature of science might go about creating classroom environments in which students own life interests are a central focus of their learning activities. Such learning environments would be of considerable interest to science educators worldwide who are interested in constructivist-related pedagogical reform which builds on students' extant perspectives, interests and goals (about learning and about themselves).

In the context of his special Year 9 class, Fred emphasises learning (rather than teaching); learning to act scientifically in life. And he endeavours to ensure that students' own life interests are a central focus of their activities. This case study has shown how, through the agency of experimental inquiry, Fred endeavours to promote a spirit of *critical social inquiry* in his Year 9 science class. He values empowering students as inquirers who have the skills and confidence to think self-critically about their own ideas and understandings and to challenge the knowledge claims of others. But he realises that a supportive learning environment is required to foster critical inquiry, one in which students can trust the teacher to respect them and to protect them from the social excesses of their peers. Thus, Fred is careful to engage the class in *open discourse* in which students learn to listen attentively to others and to disclose their own thoughts and developing ideas.

Fred's views on school science as a *process of inquiry*, as represented in his responses to the first part of the BASSQ (see Fig 1), are well borne out in his Year 9 classroom actions, as evidenced by The First Five Minutes tale. However, his views on the *uncertainty of scientific knowledge* (see Fig 1) do not effect his classroom actions in such a straightforward manner. Although he espouses a strongly relativist epistemology and claims to give voice to it in his Year 12 Biology class, in his Year 9 science class his pragmatic concern for the intellectual and emotional immaturity of the students results in a more objectivist epistemology of practice. Although he does not actively promote epistemic certainty as a Year 9 pedagogical goal, neither does he address it as an issue in classroom critical discourse, preferring to enable these students to construct a stable platform of 'concrete' understanding upon which to become critical social inquirers.

This research also has contributed in a significant way to strengthening a unique cross-national research relationship between Peter and Chen, one that promises to add an enriching *cross-cultural perspective* to their understanding of their own culture's practices of science education.

As they continue to work together, each is helping the other 'fish' to become increasingly aware of the (invisible) 'water' in which it is immersed.

REFERENCES

Aldridge, J., Taylor, P.C., & Chen, C. (1997, Mar). *Development, validation and use of the Beliefs About Science and School Science Questionnaire (BASSSQ).* Paper presented at the annual meeting of the National Association for Research in Science Teaching (NARST)

Dawson, V.M. & Taylor, P.C. (1998, Apr). *(A professor's) editorial and (a student's) authorial voice: Getting the balance right.* Paper presented at the annual meeting of the National Association for Research in Science Teaching (NARST). San Diego, CA.

Dawson, V. & Taylor, P.C. (in press). Establishing critical and open discourses in the science classroom: Reflecting on initial difficulties. *Research in Science Education.*

Denzin, N. & Lincoln, Y. (1994). *The handbook of qualitative research in education.* Newbury Park, CA: Sage.

Erickson, F. (1986). Qualitative methods in research on teaching. In M.C. Wittrock (Ed.), *Handbook of research on teaching* (3rd ed., pp. 119-159). NY: Macmillan.

Guba, E.G. & Lincoln, Y.S. (1994). Competing paradigms in qualitative research. In N.K. Denzin and Y.S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 105-117). Thousand Oaks, CA: Sage Publications.

Shulman, L. (1992). Towards a pedagogy of cases. In J. Shulman (Ed.), *Case methods in teacher education.* New York: Teachers College Press.

Slattery, P. (1995). *Curriculum development in the postmodern era.* New York: Garland Publishing.

Taylor, P.C. (1996). Mythmaking and mythbreaking in the mathematics classroom. *Educational Studies in Mathematics*, 31, 151-173.

Taylor, P.C. (1997, Mar). *Telling tales that show the brushstrokes*. Paper presented at the annual meeting of the National Association for Research in Science Teaching, Chicago, IL.

Taylor, P.C. (1998). Constructivism: Value added. In B. Fraser & K. Tobin (Eds.), *The international handbook of science education* (pp. 1111-1123). Dordrecht, The Netherlands: Kluwer Academic Press.

Taylor, P.C.& Cobern, W.W. (1998). Towards a critical science education. In W.W. Cobern (Ed.), *Cultural perspectives on science education*. Dordrecht, The Netherlands: Kluwer Academic Press.

Taylor, P. & Campbell-Williams, M. (1993). Discourse toward balanced rationality in the high school mathematics classroom: Ideas from Habermas's critical theory. In J.A. Malone & P.C.S. Taylor (Eds.), *Constructivist interpretations of teaching and learning mathematics* Proceedings of Topic Group 1C at the Seventh International Congress on Mathematical Education (pp. 135-148). Perth, Australia: Key Centre for School Science and Mathematics, Curtin University of Technology.

Taylor, P.C. & Dawson, V.M. (in press). Critical reflections on a problematic student-supervisor relationship. In J. Malone, W. Atweh, & J. Northfield (Eds.), *Research supervision in mathematics and science education*. Hillsdale, NJ: Lawrence Erlbaum.

Taylor, P.C. & Geelan, D.R. (1998, Apr). *Writing one's lived experience: Beyond the (pale) hermeneutic?* Paper presented at the annual meeting of the National Association for Research in Science Teaching (NARST). San Diego, CA.

Taylor, P.C., Fraser, B.J. & Fisher, D. (1997). Monitoring constructivist classroom learning environments. International Journal of Educational Research, 27(4), 293-302.

Tobin, K. & McRobbie, C.J. (1996). Cultural myths as constraints to the enacted curriculum. *Science Education 80*(2), 223-241.

Van Maanen, J. (1988). *Tales of the field: On writing ethnography*. Chicago: The University of Chicago Press.

Van Manen, M. (1991). *The tact of teaching: The meaning of pedagogical thoughtfulness*. Albany, NY: SUNY.

APPENDIX

REVISING THE BELIEFS ABOUT SCIENCE AND SCHOOL SCIENCE QUESTIONNAIRE (BASSSQ)

Our trials amongst Australian and Taiwanese junior science teachers of the *Beliefs About Science and School Science Questionnaire (BASSSQ)* indicated interpretive difficulties; notably that many teachers could not differentiate conceptually between the *Science* and *School Science* scales (Aldridge, Taylor & Chen, 1997). Thus, for our subsequent case studies we decided to use only the School Science scale, which asks teachers about what type of science (along a postmodern-objectivist continuum), in their opinion, **should** occur in their school science classroom. Thus, the revised 14-item *Beliefs About School Science Questionnaire (BASSQ)* (attached) aims to obtain a measure of teachers' idealised views about the nature of school science. The School Science scale comprises two sub-scales: *Process of Inquiry* and *Status of Knowledge*.

For the revised 14-item BASSQ, we combined the data from the Taiwan (N=50) and Australian (N=50) teachers and examined the internal consistency of the sub-scales. Table 1 indicates that both sub-scales have high degrees of internal consistency. Our next step (beyond this paper) is to examine the discriminat validity and factor structure of the revised BASSQ.

Table 1
Internal Reliability of revised BASSQ
(Australian & Taiwan teacher data combined)

Scale	Process of Inquiry	Status of Knowledge
Alpha	0.88	0.89
N (Twn+Aus)	98	94
Items	7	7

Profile of Fred's Beliefs about School Science

For our Australian case study, we chose a junior science teacher who we believed might hold a relatively *postmodern* view of the nature of science. We asked Fred to respond to the beliefs about science questionnaire in the context of his teaching junior science, and his results for the 14-item BASSQ are displayed in Figure 1. Items 1-7 comprise the Process of Inquiry sub-scale and items 8-14 comprise the Status of Knowledge sub-scale. The questionnaire cotains a five-point Likert-type frequency response scale with scores ranging from 5 (Almost Always) to 1 (Almost Never).

Science as a Process of Inquiry

On the Process of Inquiry sub-scale, the results indicate that Fred believes that students in this class should 'often' or 'almost always' be provided opportunities to engage in exploratory, problem-solving and collaborative inquiry (items 1-6), but only 'sometimes' should they be taught to differentiate between theory and observation (item 7).
Overall, the results suggest that Fred holds a relatively strong postmodern view of school science as a discursive experimental activity.

Uncertainty of Scientific Knowledge

However, Fred's response to the Status of Knowledge sub-scale was less consistent. He believes that students should 'almost always' learn about the tentativeness of scientific knowledge (item 12) and 'often' should learn to be critical of accepted theories, examine the history of scienctific knowledge, and the social issues that shape and are shaped by scientific knowledge (items 8,9,13,14). However, he believes that only sometimes should students learn about the provisional nature of sciecntific theories (items 10,11). *Overall, Fred seems to believe that the issue of the uncertainty of scientific knowedge should be part of the science curriculum.*

The results of the BASSQ suggest that Fred attaches more importance to engaging his junior science students in doing science and relatively less importance to enagaging them in reflecting on the epistemological status of scientist's knowledge claims.

Fred Compared With Other Teachers

We calculated the mean sub-scale scores for each of the Australian and Taiwanese teacher groups and compared them with Fred's scores. The data are shown in Table 2 and are illustrated in Figure 2. The results must be treated with cautin until we have ascertained the robustness of the factor structure of the questionnaire and the discrimiant validity of the sub-scales.

At this stage, it appears that Fred holds an idealised view of school science that is slightly more postmodern than the group of Australian teachers. The results indicate also that the Australian teachers' view is more postmodern than the Taiwanese teachers' view.

However, further statistical analyses are needed before these results can be regarded as truly indicative of significant differences in Australian and Taiwanese science teachers' beliefs.

Table 2
Item & Scale Mean Scores of revised BASSQ
(Fred, Aust teachers, Taiwan teachers)

	BASSQ Scales					
	Process of Inquiry			Status of Knowledge		
BASSQ Items	Fred	Aust (n=50)	Twn (n=50)	Fred	Aust (n=50)	Twn (n=50)
1&8	5	3.94	3.57	4	3.54	3.00
2&9	5	4.10	3.98	4	3.46	2.98
3&10	5	4.18	3.79	3	3.78	2.96
4&11	4	4.20	3.59	3	3.72	3.00
5&12	4	4.08	3.29	5	4.02	3.94
6&13	4	4.26	3.79	4	3.44	2.94
7&14	3	4.30	3.88	4	3.72	3.18
Scale Mean	4.29	4.15	3.69	3.86	3.67	3.14

Fig 1.
Fred's Beliefs about School Science

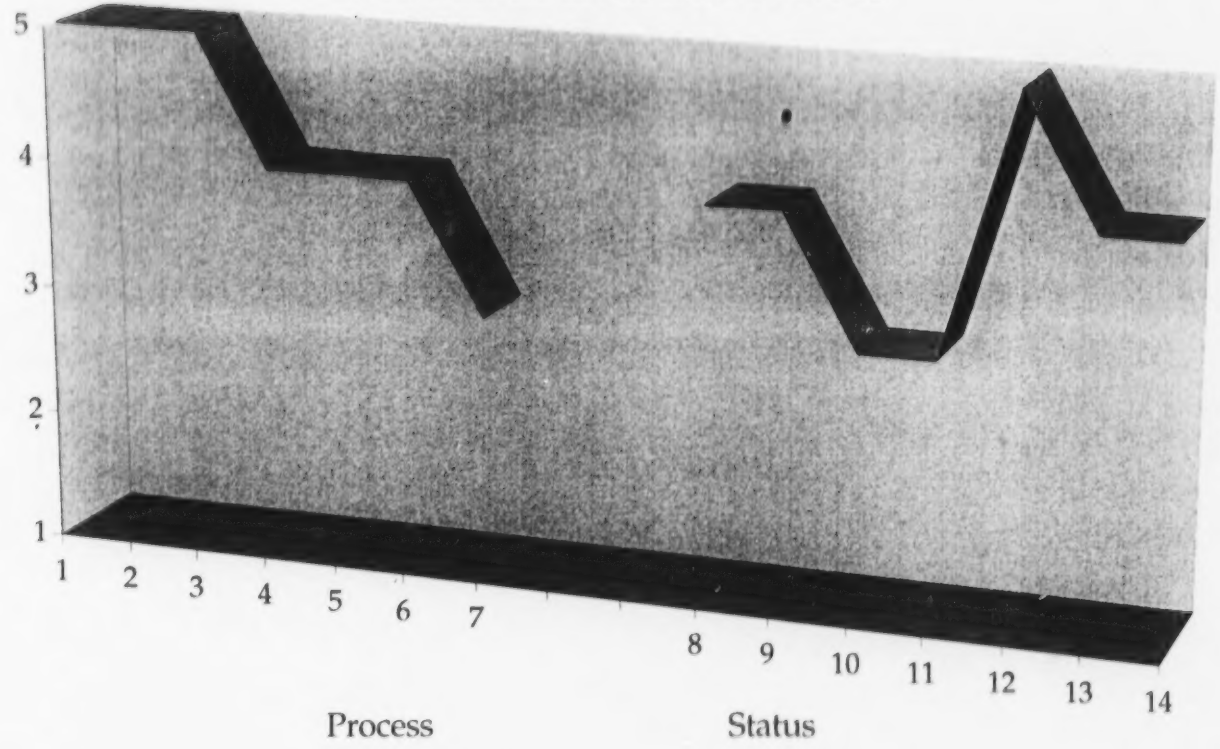

Fig 2.
Teachers' Beliefs about School Science